# Analysis of Reformulated Gasoline: MTBE, Ethanol, and Alkylate Alternatives

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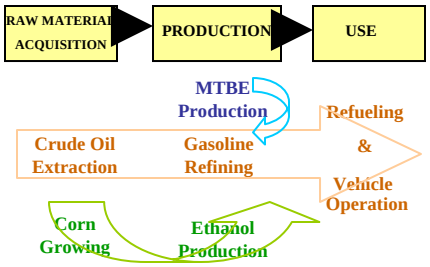
## Abstract

A streamlined Life Cycle Assessment (LCA) is being completed for the processes to generate and use reformulated gasoline, including MTBE, ethanol, and alkylate alternatives, for a vehicle traveling 12,000 miles in a year. The results of the study will be submitted to EPA's Office of Transportation and Air Quality for peer review and consideration in any further deliberations. While the study is expected to provide decision makers with greater information about the potential effect within select impact categories, such as ozone depletion, global warming, smog formation, acidification, eutrophication, and human health effects, it is anticipated that tradeoffs will be apparent and that none of the three systems will be the "best" in all categories. Data gaps within the systems are also being documented which could be pursued with more detailed analysis in future efforts.

## Life Cycle Assessment

LCA is a valuable analytical tool because it considers the many emission sources that can combine to produce environmental impacts, and because it considers multiple impacts. (1) The analysis of multiple impacts is especially important because it can alert a decision-maker to unexpected effects of policy/management decisions.




## Background

In the case of fuel additives, MTBE was introduced to improve air emissions from vehicles but led to problems with drinking water. Using emissions data collected in conjunction with the Office of Pollution Prevention and Toxics and the Office of Transportation and Air Quality, Life Cycle Inventory data were collected and assembled in EXCEL spreadsheets. The Tool for the Reduction and Assessment of Chemical and other environmental Impacts (TRACI) is currently being used to conduct an impact assessment comparing MTBE, ethanol, and alkylated reformulated gasoline as alternatives. (2)

## Inventory

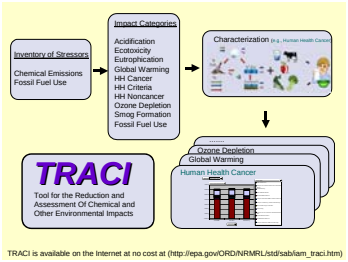
For the inventory portion of the LCA used in this study, only publicly-available data was used. The intent was to maintain as much transparency in the data as possible. However, the use of data sets that were collected for purposes other than a life cycle inventory can be problematic at times. Additional data concerns are identified in the project.

Processes/data addressed in this study include: crude oil extraction, various transportation steps, refining (for the products and for transportation fuels), corn growing (including the application of fertilizers and pesticides), ethanol production, electricity production for fuel/energy use throughout the life cycle, leaks from storage tanks, and vehicle refueling and operating emissions.

The inventory data were collected and manipulated using spreadsheets. The spreadsheets allowed the tracking of changes that were made to the data as well as documentation of data sources and calculation methods. Most of this utility can only be viewed through the running of the spreadsheet software (e.g., through examining cell formulas and the use of the command: Tools Auditing Trace Dependence/Precedence).

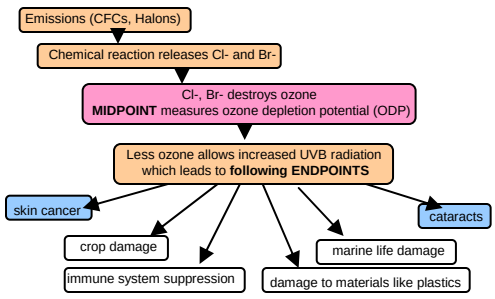
## TRACI

This case study uses TRACI for the life cycle impact assessment (LCIA). The results in TRACI's categories are indicators of relative effects and often illustrate that one alternative is better in one impact category but worse in another. Thus, the results normally represent tradeoffs. The comparison of options over the entire life cycle (i.e., cradle to grave) and over various media is inherent to LCA methodology.




## Midpoint Impact Assessment

As the National Risk Management Research Laboratory had already made the decision not to aggregate between environmental impact categories, many of the impact assessment methodologies within TRACI are based on "midpoint" characterization approaches. (3) The impact assessment models reflect the relative potency of the stressors at a common midpoint within the cause-effect chain; see the example for ozone depletion. This diagram shows that characterization could take place at the level of midpoints such as ozone depletion potential (midpoint) or endpoints (e.g., skin cancer, crop damage, immune system suppression). Analysis at a midpoint minimizes the amount of forecasting and effect modeling incorporated into the LCIA, thereby reducing the complexity of the modeling and often simplifying communication.




## Life Cycle Impact Assessment

Life cycle impact assessment is different from risk assessments that are often very narrowly focused on a single chemical at a very specific location. In the case of risk assessment it is possible to conduct very detailed modeling of the predicted impacts of the chemical on the population exposed and even to predict the probability of the population being impacted by the emission. In the case of Life Cycle Impact Assessment (LCIA) thousands of chemical emissions (and resource stressors) which are occurring at various locations are evaluated for their potential impacts in multiple impact categories. The sheer number of stressors being evaluated, the variety of locations and the diversity of impact categories makes it impossible to conduct the assessment at the same level of rigor as a traditional risk assessment. Instead, LCIA models are based on the accepted models within each of the impact categories using assumptions and default values as necessary to simplify the characterization. The resulting models that are used within LCIA are suitable for relative comparisons, but not sufficient for absolute predictions of risk.

## References

1) Curran, M.A. (ed.), *Environmental Life-Cycle Assessment*. McGraw-Hill, New York, New York, 1996.
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3) Bare, J.C., P. Hofstetter, D.W. Pennington, and H.A. Udo de Haes, "Life Cycle Impact Assessment Midpoints vs. Endpoints – the Sacrifices and the Benefits," *the International Journal of Life Cycle Assessment*, Vol. 5, No. 6, Nov. 2000.

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